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A RELATIONSHIP BETWEEN OCEAN CIRCULATION AND VOLUME  
REGENERATION IN THE (U) NAVAL UNDERWATER SYSTEMS  
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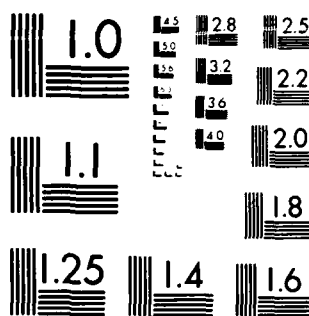
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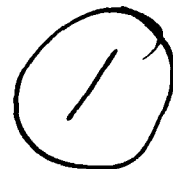
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# **A Relationship Between Ocean Circulation and Volume Reverberation in the Subarctic Northeast Pacific Ocean (Gulf of Alaska)**

**A Paper Presented at the  
111th Meeting of the Acoustical Society of America,  
Cleveland, Ohio, 12-16 May 1986**

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**R. G. Turner  
J. W. Power  
Defence Research Establishment Pacific**

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**Naval Underwater Systems Center  
Newport, Rhode Island / New London, Connecticut**

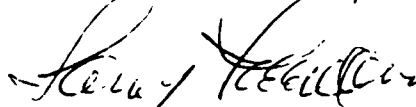
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## PREFACE

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19. ABSTRACT (Continue on reverse if necessary and identify by block number) Earlier investigations have shown a significant change in integrated scattering and spectral characteristics when transmitting into the subarctic (above 40 north latitude) northeast Pacific Ocean. An analysis of an extensive series of volume reverberation measurements obtained by Turner indicates a strong influence of the counterclockwise circulation around the Alaskan Gyre on the distribution of scattering strengths. At higher frequencies (5-20 kHz) the greater scattering strengths are found in the relatively (warm California) undercurrent water which flows around the perimeter of the gyre. At lower (1.25-5 kHz) frequencies, the greater scattering strengths are found in the relatively cold water such is found in the upwelled subarctic water at the center of the gyre. This implies a significant change in the type of scatterers between these frequency domains. <i>Keywords:</i>					
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**A RELATIONSHIP BETWEEN  
OCEAN CIRCULATION AND VOLUME  
REVERBERATION  
IN THE  
SUBARCTIC NORTHEAST PACIFIC OCEAN  
(GULF OF ALASKA)**

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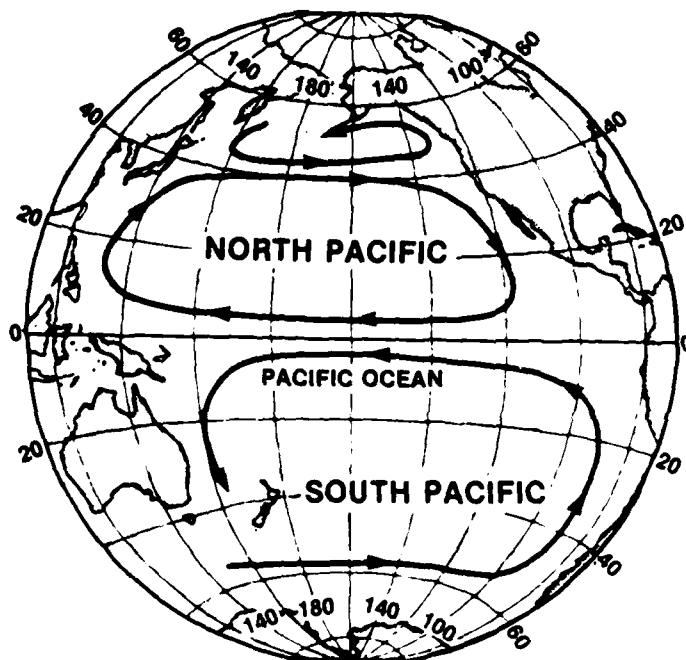
## VIEWGRAPH 1

This paper presents an apparent relationship between ocean circulation and volume reverberation in the Subarctic Northeast Pacific Ocean.

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## VIEWGRAPH 2

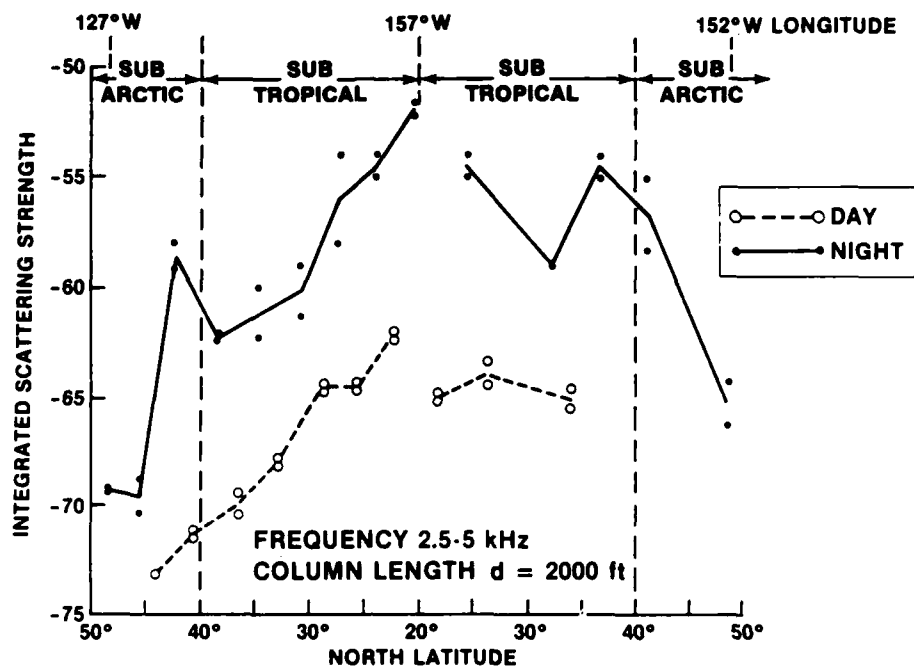
In the North Pacific Ocean the principal circulation gyre extends from the equator to only 40° North latitude (corresponding to the coast of Northern California). This leaves a large Subarctic region to the North that has its own unique characteristics.

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# **NORTH PACIFIC INTEGRATED SCATTERING STRENGTH LATITUDE DEPENDENCE (2.5-5.0 kHz BAND)**

(J.A. SCRINGER AND R.G. TURNER, J ACOUST SOC AM 54(2), 483-493, (1973))



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VIEWGRAPH 3

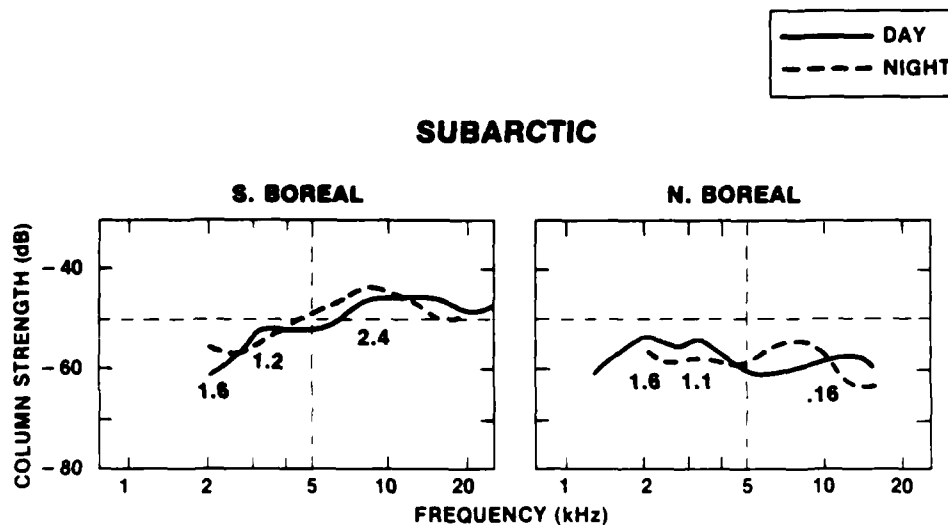
Scrimger and Turner have previously shown a significant change in integrated scattering strength when transiting into the Subarctic region. This was a track from Vancouver to Hawaii and back into the Subarctic region.

-- Next viewgraph, please. --



## NORTH PACIFIC COLUMN STRENGTH SPECTRA

(1.3) EFFECTIVE SWIM BLADDER RADIUS (cm)



(R.P. CHAPMAN et al, J ACOUSTIC SOC AM 56 (6), 1722 - 1734 (1974))

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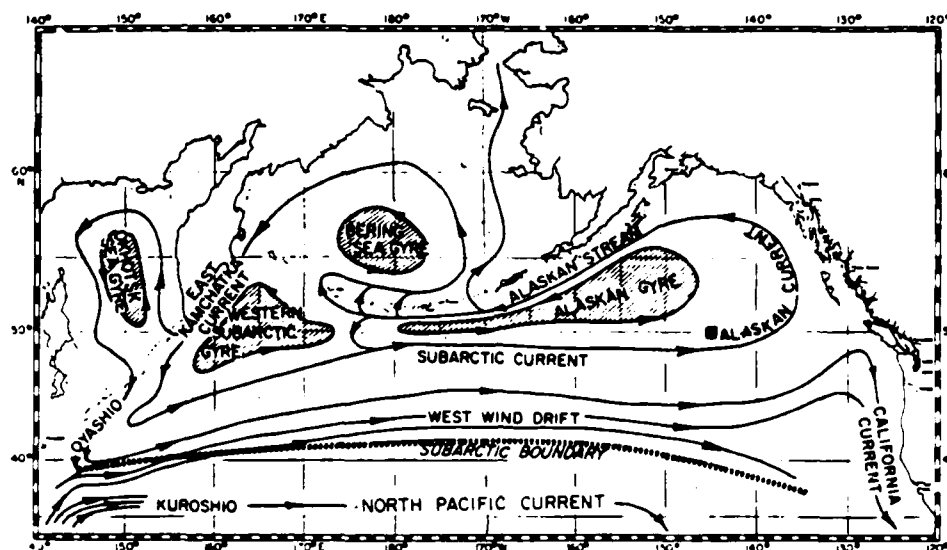
### VIEWGRAPH 4

Chapman, et al., as part of their epic circumnavigation of the western hemisphere, reported a change in the spectral content of column strength for two stations in this Subarctic region. Specifically, there appeared to be two independent mechanisms, one below 5 kilohertz and one (or more) above.

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## CIRCULATION SYSTEMS IN THE SUBARCTIC NORTH PACIFIC

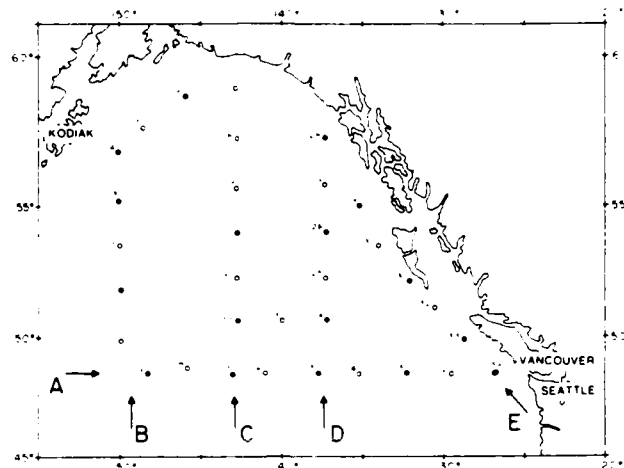


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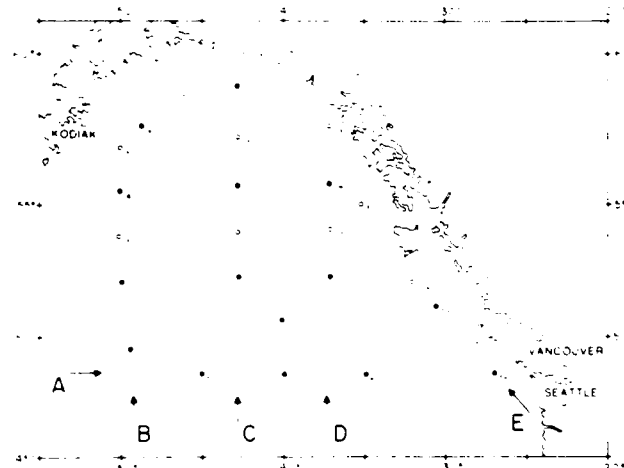
### VIEWGRAPH 5

The circulation in the Subarctic Northeast Pacific is dominated by flow around the Alaskan gyre. Relatively warm water circulates around the perimeter while relatively cold water upwells in the center of the gyre.

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September 1971 stations showing station numbers and positions. Open and closed circles indicate daytime and nighttime stations, respectively.\*



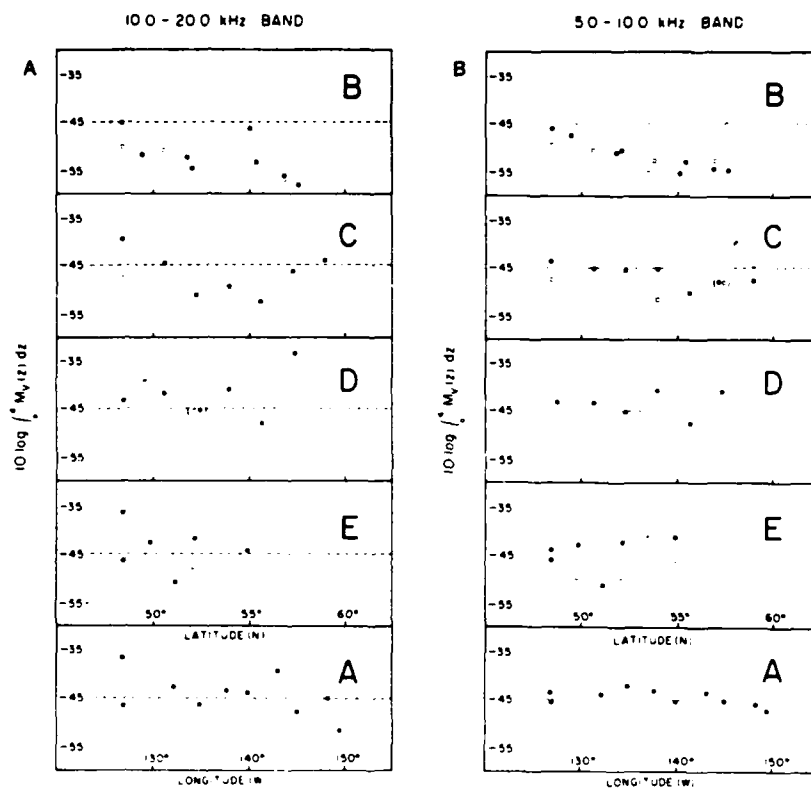
April 1972 stations showing station numbers and positions. Open and closed circles indicate daytime and nighttime stations, respectively.\*

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### VIEWGRAPH 6

To quantify volume reverberation throughout the Northeast Subarctic Pacific (Gulf of Alaska), Turner conducted an extensive series of measurements for both summer and winter conditions. The standard measurement technique with explosive sources was used and data were reported for four octave frequency bands - 1.25 to 2.5 kHz, 2.5 to 5 kHz, 5 to 10 kHz, and 10 to 20 kHz. Night stations are shown by dark circles, day stations by light circles.

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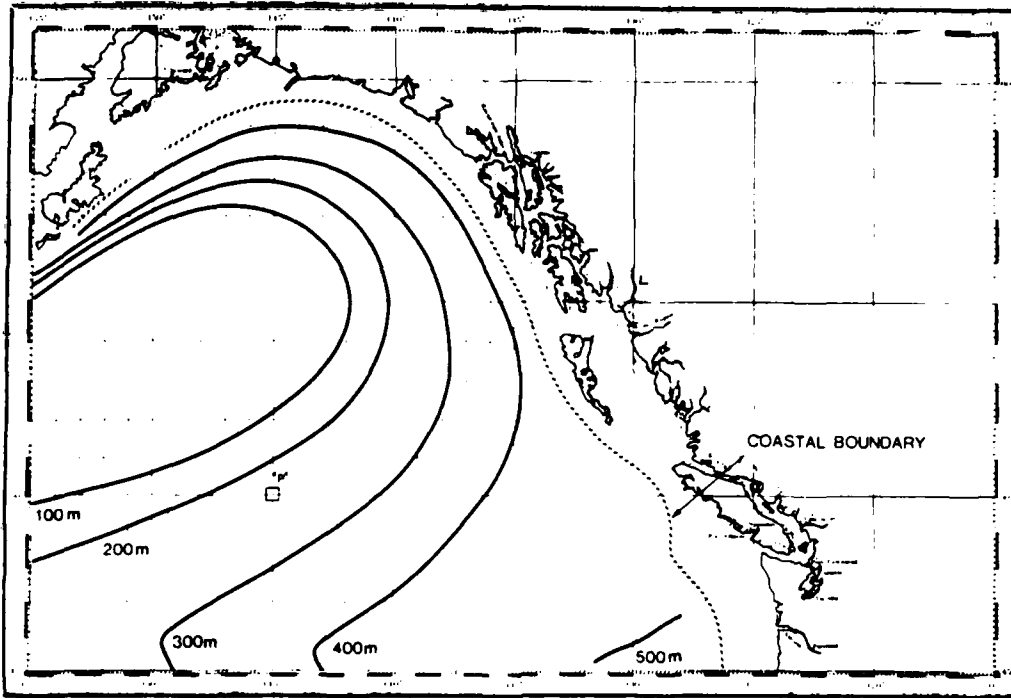
## VIEWGRAPH 7

Turner initially plotted the data as a function of latitude for all but one track. Typical results are shown here for the 10 to 20 kHz and 5 to 10 kHz bands. Rather than showing a simple trend the data have some unexpected changes.

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## CONTOURS OF THE AXIS DEPTH OF THE DEEP SOUND CHANNEL (SUMMER)



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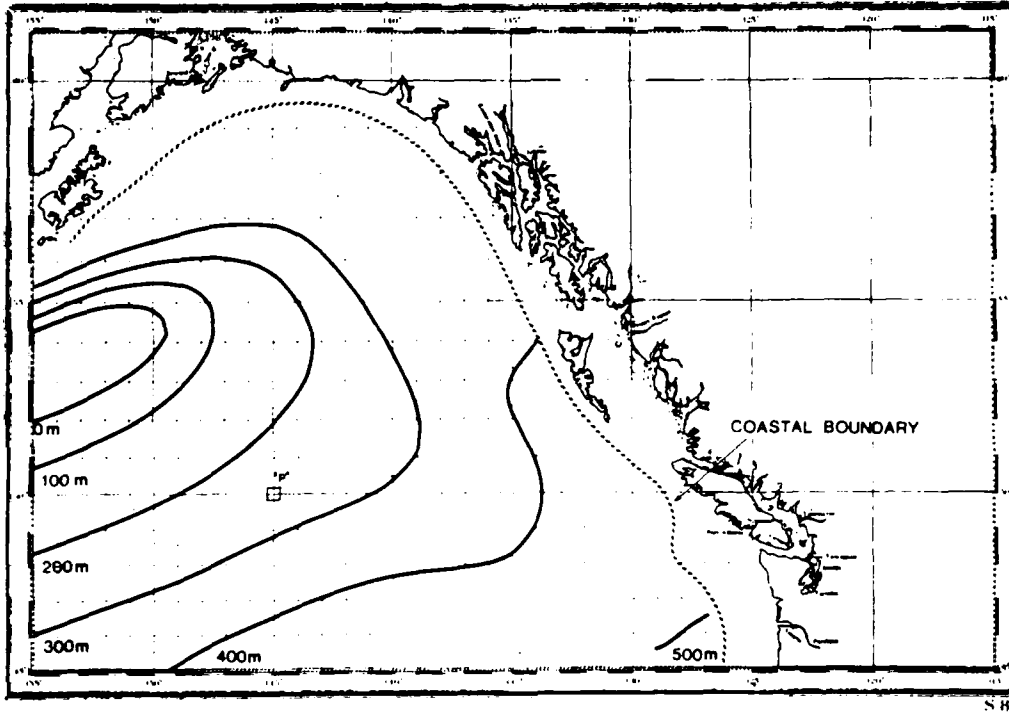
### VIEWGRAPH 8

Recently Powell, Chow, and Browning have shown that the depth of the deep sound channel axis in the Subarctic Northeast Pacific does not decrease with latitude but rather contours are concentric about the Alaskan gyre. The deepest axis depth is associated with the warm water around the perimeter, the shallowest with the cold water in the center of the gyre.

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## CONTOURS OF THE AXIS DEPTH OF THE DEEP SOUND CHANNEL (WINTER)



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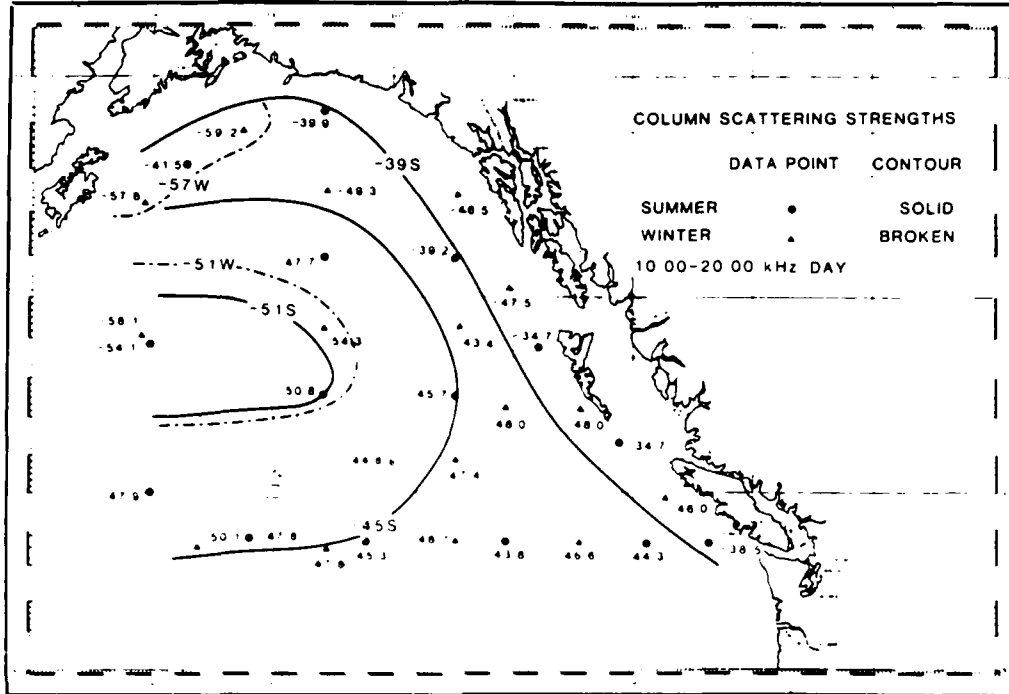
### VIEWGRAPH 9

This pattern intensifies under winter conditions with the axis reaching the surface in the center of the gyre.

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## COLUMN SCATTERING STRENGTH MEASUREMENTS AND CONTOURS FOR THE 10-20 kHz BAND



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### VIEWGRAPH 10

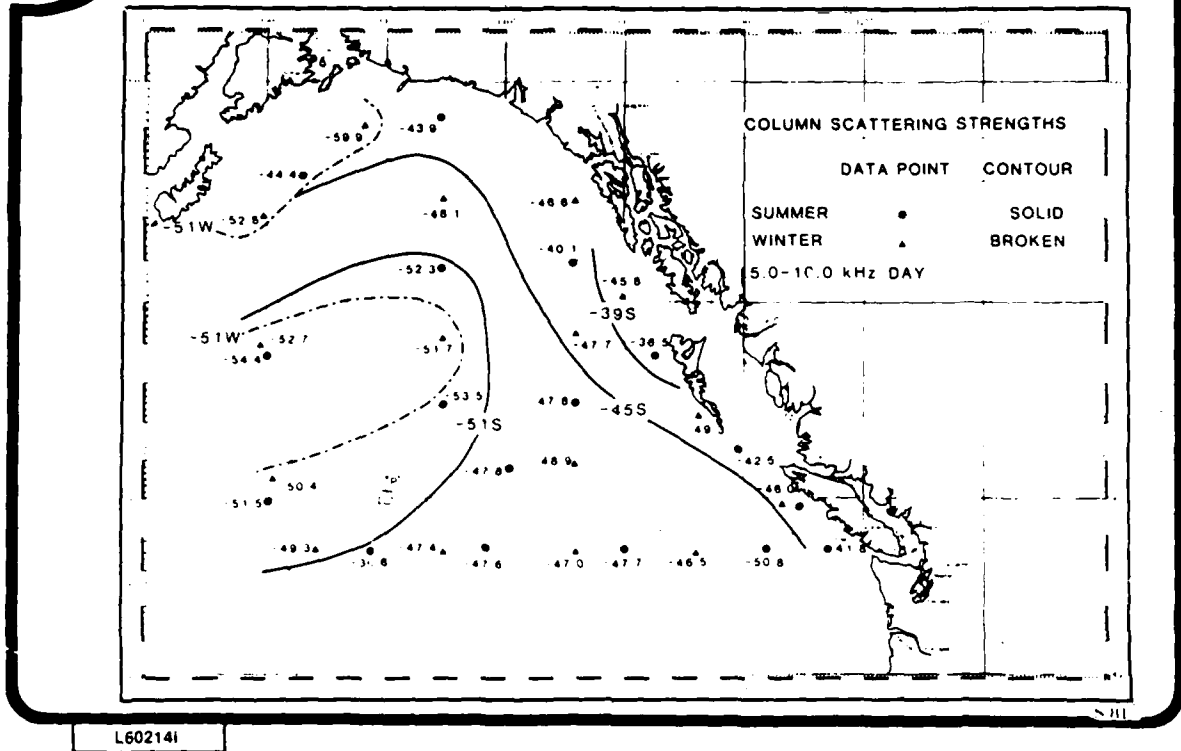
It seemed logical to analyze Turner's data to see if a similar pattern developed. Here is the result for the highest frequency band (10 to 20 kilohertz), the solid contours are for summer, the dashed contours for winter. The highest column scattering strengths are associated with the warmer water around the perimeter of the gyre; here levels are generally lower under winter conditions.

The lowest levels are found in the colder water at the center of the gyre.

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## COLUMN SCATTERING STRENGTH MEASUREMENTS AND CONTOURS FOR THE 5-10 kHz BAND



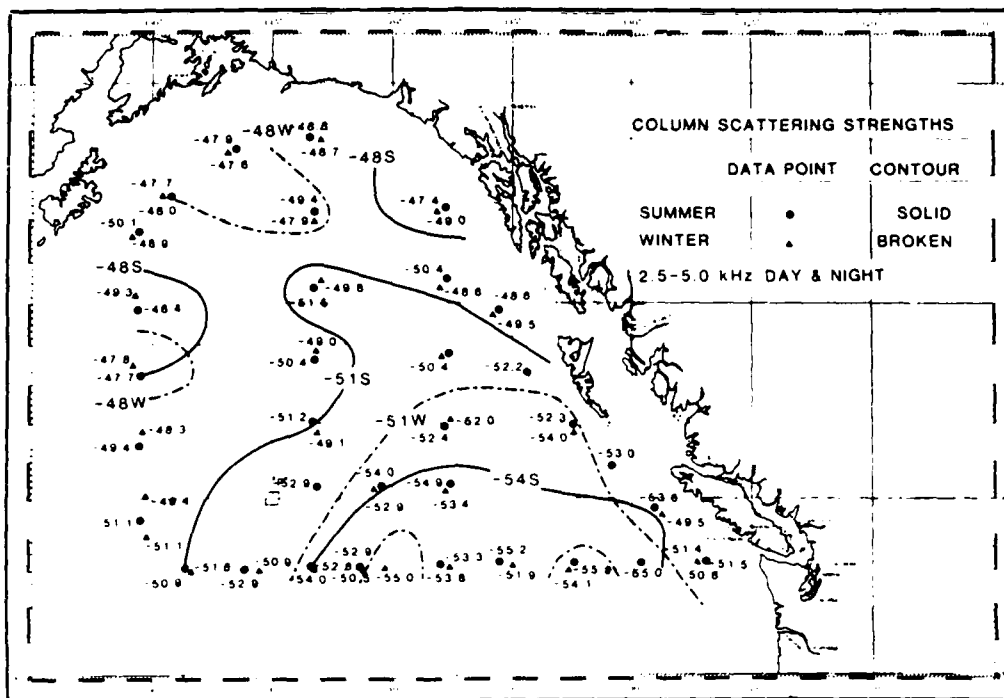
VIEWGRAPH 11

A similar pattern is found for the next lower frequency band, 5 to 10 kilohertz. In all these figures, we are showing day stations only.

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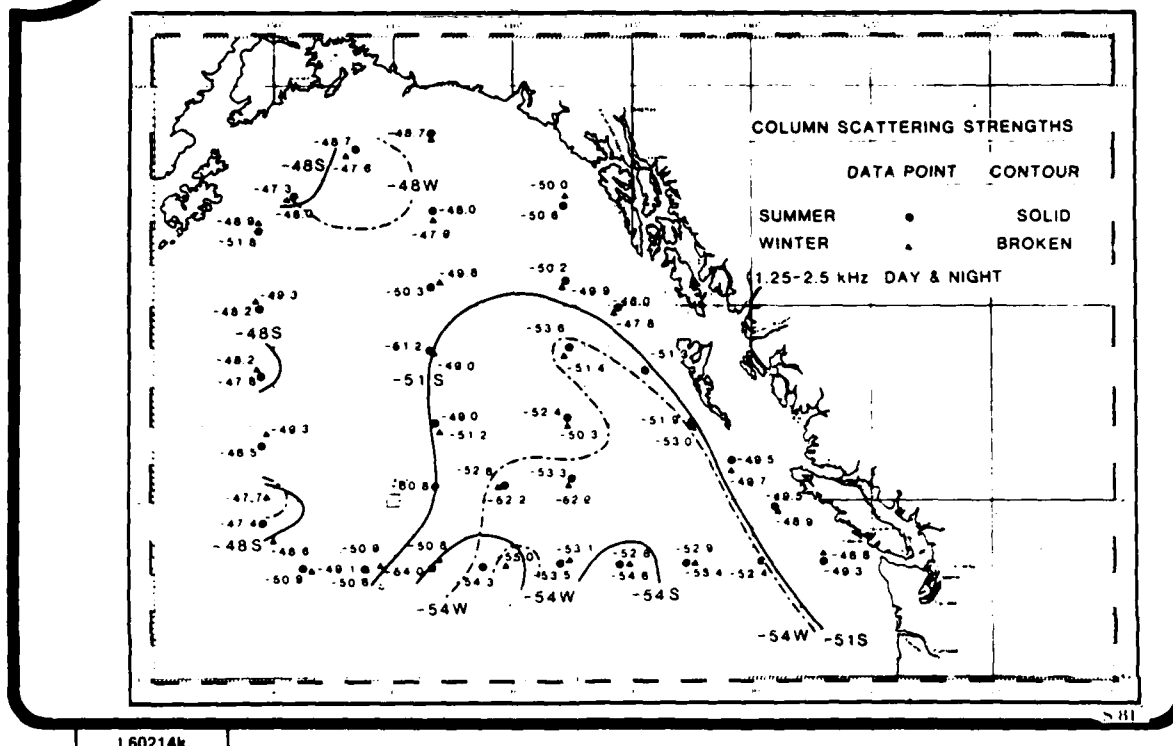


## COLUMN SCATTERING STRENGTH MEASUREMENTS AND CONTOURS FOR THE 2.5-5 kHz BAND





## COLUMN SCATTERING STRENGTH MEASUREMENTS AND CONTOURS FOR THE 1.25-2.5 kHz BAND



VIEWGRAPH 13

This pattern is confirmed by the lowest frequency band, 1.25 to 2.5 kilohertz. As Chapman's earlier work had indicated, we appear to have two distinct and independent frequency regimes with the demarcation being at 5 kilohertz.

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## **CONCLUSIONS**

### **SUBARCTIC NORTHEAST PACIFIC OCEAN (GULF OF ALASKA)**

- **AT HIGHER FREQUENCIES (5-20 kHz)  
GREATER VOLUME REVERBERATION FOUND  
IN WARMER WATER AROUND NORTHERN  
AND EASTERN PERIMETER OF ALASKAN GYRE**
- **AT LOWER FREQUENCIES (1.25-5 kHz)  
GREATER VOLUME REVERBERATION FOUND  
IN COLDER WATER UPWELLED IN THE  
CENTER OF THE ALASKAN GYRE**
- **RESULTS SUGGEST THE POSSIBILITY OF TWO  
DISTINCT SCATTERING REGIMES  
AND MECHANISMS**

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#### **VIEWGRAPH 14**

We can summarize our results as follows:

- At higher frequencies (5 to 20 kilohertz) greater volume reverberation is found in warmer water around the perimeter of the Alaskan gyre.
- For lower frequencies (1.25 to 5 kilohertz) greater volume reverberation is found in relatively colder water.

These results suggest the possibility of two distinct scattering regimes and mechanisms.

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